COURSE CONTENT

Academic Year	AY2023-24	**Semester**	1
School/Programme	EEE / Master of Science (CCA)		
Course Code	EE6222		
Course Title	Machine Vision		
Pre-requisites	Linear Algebra, Probability, Signals & Systems		
No of AUs	3		
Contact Hours	39 (3h lecture per week)		
Expected Implementation date of new/revised course	7 August 2023		

Any cross-listing?
Is course opened to all Postgraduate students (including IGP) or specific program (please indicate)?

Yes

Within EEE							Outside EEE (Please specify)
MSc Programmes*					MEng	PhD	
CME	CCA	ET	PE	SP			
GE	SE	GE	GE	GE	√	√	*All Postgraduate research students under CoE and IGP*

* List of MSc programmes
- MSc Communication Engineering (CME) Programme
- MSc Computer Control & Automation (CCA) Programme
- MSc Electronics (ET) Programme
- MSc Power Engineering (PE) Programme
- MSc Signal Processing (SP) Programme

Course Aims

This course aims to introduce to students the basic concepts of vision-based automation systems in industrial and practical settings. Vision-based automation system involve image processing and analysis, video analysis, three-dimensional data processing, machine learning and intelligence. This course covers these topics appropriately.

Intended Learning Outcomes (ILO)

By the end of this course, students would be able to:
1. Understand the basic concepts of image pre-processing & analysis, feature extraction and pattern classification.
2. Understand the basic concepts of three-dimensional image and video analysis and recognition.
3. Apply the machine vision concepts to develop simple automation systems.
4. The students should be able to understand fundamental theories and algorithms in machine learning. Understand deep neural networks and know how to leverage them in solving complex computer vision problems in automation systems.

Course Content

Machine Vision plays a major role in automation. This course is centered around the usage of images, videos and other visual information for automation. Hence, this course covers image processing, image analysis, image recognition, machine learning, video recognition, three-dimensional machine vision and their applications in automation.

Course Outline:

Fundamentals of Image, Processing and Transforms (6 hours)
Image formation. Pre-processing. Spatial domain & frequency domain operations.

Image Denoising, Enhancement and Manipulation (6 hours)
Nonlinear processing and Histogram equalization. Rank order statistical filter, Binary and gray-scale morphological operations. Local orientation of image.

Decision, Classification and Machine Learning (9 hours)
Decision boundaries. Machine learning for decision. Unsupervised learning and K-means clustering. Nearest neighbor classifiers, Linear classifiers, Minimum distance classifiers, Neural networks, Deep convolutional neural networks and their application in machine vision.

Visual Data Dimensionality Reduction (6 hours)
Data representation, Eigenvalue and eigenvectoer decomposition, principal component analysis, Linear discriminant analysis, critical roles of dimensionality reduction in visual data recognition.

Three-dimensional Machine Vision (6 hours)
Reflectance map, shape from shading, Stereovision techniques. Motion detection, Surface recovery from range data. Binocular stereo vision. Model-based recognition. 3D model representations.

Video Recognition (6 hours)
Video representation, Spatio-temporal feature extraction from video, Gesture recognition, Action recognition and activity recognition.

Assessment (includes both continuous and summative assessment)

Component	Course ILO tested	Weightage	Team/Individual	Assessment Rubrics
Final Exam	1, 2, 3	60%	Individual	
Quiz	1, 2	10%	Individual	
Two take home assignments	1, 2, 3, 4	30% (15% each)	Individual	
Total		100%		

Description of Assessment Components:
There will be one quiz conducted on week 7 lasting 30 minutes to test students' basic understanding of topics covered. There will be two take home assignments to cover comprehensive analysis and design of machine vision systems.
There will be final examination lasting 3 hours in the university exam period to test students' comprehensive understanding of all major topics covered in the whole course.

Formative feedback

The two Take Home Assignments and Quiz are designed to test students' level of understanding on what have been learned from the lectures. All these provide students with their learning progress and feedback. Students will receive feedback from the Take Home Assignments and Quiz they have taken. Students can also discuss with lecturers and receive feedback on their learning.

Learning and Teaching Approach

Approach	**How does this approach support the students in achieving the learning outcomes?**
Weekly lecture content and video recordings including 20% to 30% TEL online learning	Theoretical content and real-life examples will be presented by instructors. Students will be taught about the important concepts, methodologies and techniques in machine vision.
Quiz	To test students' general understanding of basics of the course and provide feedback on their learning.
Take home assignments	Written home assignments, including programming work, covering all topics to test students' understanding in more depth than what are possible with formal written exams on analysis, design and implementation issues.
Final Exam	To test students' fundamental knowledge and analytical skill.

Reading and References

1. Davies E. R., Computer Vision: Principles, Algorithms, Applications, Learning, Elsevier Science, Academic Press, 2017.
2. Rafael C. Gonzalez, Richard E. Woods, Digital image processing, Pearson, 4th Edition, 2018
3. Duda R. O., Hart P. E. , and Stork D. G., Pattern Classification, John Wiley & Sons, 2001.

Course Policies and Student Responsibilities

(1) General

You are expected to complete all assigned pre-class readings and activities, attend all seminar classes punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements for seminar sessions they have missed. You are expected to participate in all seminar discussions and activities.

(2) Absenteeism

Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a

student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the Academic Integrity Intranet Site for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email

Industry Participation

Company Name	Description of involvement (e.g., co-curation of course, speaker or instructor), include no. of course hours if known.	Contact Person	Email
Institute of Infocomm Research	12 course hours of industrial lecture		

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Image Fundamentals and Human Perception	1, 2	Lecture notes, Text book
2	LSI Systems and Transformations	1, 2	Lecture notes, Text book
3	Image Denoising and Enhancement	1, 2, 3	Lecture notes, Text book
4	Morphological Image Processing	1, 2, 3	Lecture notes
5	MAP Decision and Classifiers	1, 2, 3	Lecture notes, Homework Assignment 1
6	Machine Learning and Connectionist Approaches	1, 2, 3	Lecture notes, Quiz
7	Deep Convolutional Neural Networks in Machine Vision	1, 2, 3, 4	Lecture notes,

			Assignment 2 Project
8	Three-dimensional Machine Perception	1, 2, 3	Lecture notes
9	Three-dimensional Machine Vision	1, 2, 3	Lecture notes
10	Video Analysis	1, 2, 3	Lecture notes
11	Video Recognition	1, 2, 3	Lecture notes, Homework Assignment 1 Due
12	Eigenvalue and Eigenvector decomposition of data matrix	1, 2, 3, 4	Lecture notes
13	Visual Data Dimensionality Reduction	1, 2, 3, 4	Lecture notes, Assignment 2 Project Due